Echo Board Review
ACC FIT: Iowa. April 2021

Evaluation of Right Ventricle & Pulmonary Hypertension

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No relevant disclosures
Objectives

1. Describe the essential echocardiographic views for assessing the right ventricle (RV)
2. List the various measures of RV function and identify abnormal values
3. Evaluate hemodynamic status of the RV and pulmonary circulation using Echocardiography

A. Use above knowledge in the evaluation & management of your patients
B. Reinforce some key test concepts as you prepare for Echo Boards
Question 1

Which of the following statements regarding Echocardiographic assessment of the right ventricle is true?

A. TAPSE is a more reliable marker of RV systolic function than FAC in post cardiac surgery patients
B. Aging is associated with a decline in RV ejection fraction
C. RV Tei index (RIMP) is a load independent measure of RV function
D. All of the above statements are true
E. None of the above is true
Question 3

• Which of the following patients has the highest right atrial pressure?

<table>
<thead>
<tr>
<th></th>
<th>IVC Maximal diameter</th>
<th>IVC minimal diameter</th>
<th>Hepatic vein systolic filling fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.5</td>
<td>0.6</td>
<td>65%</td>
</tr>
<tr>
<td>B</td>
<td>2.2</td>
<td>1.0</td>
<td>56%</td>
</tr>
<tr>
<td>C</td>
<td>1.8</td>
<td>1.1</td>
<td>40%</td>
</tr>
<tr>
<td>D</td>
<td>2.0</td>
<td>1.0</td>
<td>59%</td>
</tr>
</tbody>
</table>

A. Patient with Pulmonary acceleration time of 128 msec
B. Patient with Peak TR velocity of 2.8 m/sec and RVOT VTI of 21
C. Patient with early diastolic PR velocity of 2.7 m and normal IVC
D. Patient with end diastolic PR velocity of 1 m, peak TR velocity of 2.5 m/s and dilated but collapsing IVC
E. None of the above

Question 4

• Further evaluation for pulmonary hypertension is most appropriate in?

A. Patient with Pulmonary acceleration time of 128 msec
B. Patient with Peak TR velocity of 2.8 m/sec and RVOT VTI of 21
C. Patient with early diastolic PR velocity of 2.7 m and normal IVC
D. Patient with end diastolic PR velocity of 1 m, peak TR velocity of 2.5 m/s and dilated but collapsing IVC
E. None of the above
The “neglected” ventricle

RV: A number of unique challenges!

• Anatomic
• Physiologic
• Technical
Technical

• Shielded by Sternum

Technical

• Depth
Recap

<table>
<thead>
<tr>
<th>Anatomic</th>
<th>Physiologic</th>
<th>Technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape: Crescentic/Triangular</td>
<td>Contraction patterns</td>
<td>Orientation (Views)</td>
</tr>
<tr>
<td>Thin wall</td>
<td>Load sensitivity</td>
<td>Retrosternal</td>
</tr>
<tr>
<td>Trabeculations</td>
<td>Adaptation</td>
<td>Near field</td>
</tr>
<tr>
<td></td>
<td>Coronary Blood flow</td>
<td></td>
</tr>
</tbody>
</table>

Goals of Assessment

1. RV size / volumes
2. RV wall thickness
3. RV systolic function
4. RV diastolic function
5. Hemodynamics
Key Windows & Views

• Parasternal:
  • PLAX
    • RV Inflow
    • RV outflow / PA
  • PSAX
• Apical
  • 4-chamber
  • RV focused 4-chamber
• Subcostal
Parasternal

Apical
Measuring RA
RV wall thickness

RV volumes

- 2d Methods
- 3D methods
## Reference Limits

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVOT PLAX</td>
<td>&gt;3.3 cm</td>
</tr>
<tr>
<td>RVOT PSAX proximal</td>
<td>&gt;2.7 cm</td>
</tr>
<tr>
<td>RV basal (Mod AP4)</td>
<td>&gt;4.2 cm</td>
</tr>
<tr>
<td>RV mid cavity</td>
<td>&gt;3.5 cm</td>
</tr>
<tr>
<td>RA</td>
<td>&gt; 5.3 /4.4 cm</td>
</tr>
<tr>
<td>RA area</td>
<td>&gt;18 cm²</td>
</tr>
<tr>
<td>RV wall Thickness (Subcostal)</td>
<td>&gt;0.5 cm</td>
</tr>
</tbody>
</table>

### RV Systolic Fn.
- Global
- EF
- ΔP/Δt
- FAC

### Regional
- TAPSE
- S’
- Strain

### RIMP

### IVA
TAPSE

- Easy
- Reproducible
- Excellent agreement
- Validated outcome data
- High specificity

- Uni-dimensional
- Regional function
- Low sensitivity
- Angle dependency
- Translational motion

Fractional Area Change (FAC)

- Validated outcome data
- Best correlation with MRI volumes
- Longitudinal + Radial Fn.

- Less IO agreement
- Regional function
- Endocardial definition
- RV size
PW TD Lateral annulus velocity

- Easy
- Reproducible
- Excellent agreement
- Validated outcome data

- Regional function
- Angle dependency
- Does not work in post Card Surgery, Transplant

Strain imaging (speckle tracking)

- Not angle dependent
- Forgiving of 2D image quality

- Regional function
- Vendor specific
- Less validated
3D Volumes, EF

- Limited experience
- Not widely available
- Time consuming (offline analysis)
- Arrhythmias
- Motion
- Image quality
- Limited prognostic data

RV dp/dt

- Global Measure
- Physiologic
- Easy and reproducible
- Forgiving of 2D image quality

- Highly load dependent
- Does not work well in > moderate TR
- Limited normative data
- No prognostic data
Tei Index (RIMP) & IVA

- Systolic + Diastolic
- Easy and reproducible
- Less load dependent
- No geometric assumptions

- Does not work well in ↑RAP
- Limited prognostic data

RIMP = (IVRT + IVCT) / ET
**RV diastolic function**

RA, IVC, Hepatic vein flow should all be an integral part of comprehensive RV assessment

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**Reference Limits**

<table>
<thead>
<tr>
<th>Function</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic (Regional)</td>
<td></td>
</tr>
<tr>
<td>TAPSE</td>
<td>&lt;1.6-1.7 cm</td>
</tr>
<tr>
<td>PWD TD annular systolic velocity</td>
<td>&lt;9.5-10 cm/s</td>
</tr>
<tr>
<td>RV FAC</td>
<td>&lt;35%</td>
</tr>
<tr>
<td>RV Strain (Mod AP4) Lateral</td>
<td>&gt;-20%</td>
</tr>
<tr>
<td>Systolic (Global)</td>
<td></td>
</tr>
<tr>
<td>RV EF (3 D)</td>
<td>&lt;44-45%</td>
</tr>
<tr>
<td>RV dP/dt</td>
<td>&lt;400 mm Hg/s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Systolo-diastolic</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tei index (RIMP)</td>
<td></td>
</tr>
<tr>
<td>PW-TDI</td>
<td>&gt;0.55</td>
</tr>
<tr>
<td>IVA: PW-TDI</td>
<td>&gt;2.2 m/s²</td>
</tr>
<tr>
<td>Diastolic</td>
<td></td>
</tr>
<tr>
<td>E/A</td>
<td>&lt;0.8-2.1</td>
</tr>
<tr>
<td>E'/A'</td>
<td>&lt;0.5-1.9</td>
</tr>
<tr>
<td>E/E'</td>
<td>&gt;6</td>
</tr>
<tr>
<td>DCT</td>
<td>&lt;120-240 msec</td>
</tr>
</tbody>
</table>

RV volumes and EF vary with age and by gender dependent. Volumes ↓ and EF ↑ in women & with advancing age.
Task Force Criteria for ARVC

Global or regional dysfunction and structural alterations

Major
2D echo criteria
Regional RV akinaesia, dyskinaesia or aneurysm and one of the following measured at end diastole
PLAX RVOT $\geq$ 32 mm
PSAX RVOT $\geq$ 36 mm
Fractional area change $\leq$ 33%

Minor
2D echo criteria
Regional RV akinaesia or dyskinaesia and one of the following measured at end diastole
PLAX RVOT $\geq$ 29 to $< 32$ mm
PSAX RVOT $\geq$ 32 to $< 36$
Fractional area change $> 33%$ to $\leq 40$

Hemodynamic assessment
Pulmonary Hypertension

1. RAP
2. RVSP (surrogate for PA systolic pressure)
3. Pulmonary Pressures (diastolic/mean)
4. RV stroke volume / cardiac output
5. Pulmonary vascular resistance
1. RAP
2. RVSP (surrogate for PA systolic pressure)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Normal (0-5 [3] mm Hg)</th>
<th>Intermediate (5-10 [8] mm Hg)</th>
<th>High (15 mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVC diameter</td>
<td>≤2.1 cm</td>
<td>≤2.1 cm</td>
<td>&gt;2.1 cm</td>
</tr>
<tr>
<td>Collapse with sniff</td>
<td>&gt;50%</td>
<td>&lt;50%</td>
<td>&gt;50%</td>
</tr>
</tbody>
</table>

Secondary indices of elevated RA pressure

- Restrictive filling
- Tricuspid E/E' > 6
- Diastolic flow predominance in hepatic veins (systolic filling fraction < 55%)

3. Pulmonary Pressures (diastolic/mean)
4. RV stroke volume / cardiac output
5. Pulmonary vascular resistance

RVSP = 4V² + RA pressure
Hemodynamic assessment
Pulmonary Hypertension

1. RAP
2. RVSP (surrogate for PA systolic pressure)
3. Pulmonary Pressures (diastolic/mean)
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\[ RVSP = 4V^2 + RA \text{ pressure} \]
Hemodynamic assessment

1. RAP
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Mean PAP = 79 - (0.45 x Pulmonary Acceleration Time)

Hemodynamic assessment
Pulmonary Hypertension

1. RAP
2. RVSP (surrogate for PA systolic pressure)
3. Pulmonary Pressures (diastolic/mean)
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\[ \text{peak TR velocity (m/s) / RVOT VTI (cm)} \times 10^{0.16} \]
Recap: Key Formulae

- RVSP = 4V^2 + RA pressure
- Pulm DP = 4V^2 (end diastolic PR) + RA pressure
- Mean PAP = Pulm DP + 1/3 PP
- Mean PAP = 79 - (0.45 x Pulmonary Acceleration Time)
- Mean PAP = 90 - (0.62 x PAT)
- Mean PAP = 4V^2 (early diastolic PR) + RA pressure
- Mean PAP = 90 - (0.62 x PAT)

{TR velocity (m/s) / RVOT VTI (cm)} x 10 + 0.16

TRV2/VTI x 5

Take Home Points

- Use multiple views / measures to make qualitative/quantitative assessment
- FAC, TAPSE, S’ using Tissue Doppler are the most established quantitative markers of RV function and should be performed
- Use right atrium, IVC and Hepatic Veins as an integral part of RV assessment
- Using validated formulae, Echocardiography can provide valuable insights into RV hemodynamic function & status of Pulm. vascular tree.
Thank you
Good Luck